RESEARCH ARTICLE | APRIL 28 2023

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AIP Conference Proceedings 2619, 090002 (2023)
https://doi.org/10.1063/5.0122581

Ethnomathematics in Sasaknese Musical Instruments: Exploration of Geometry Concept in *Gendang Beleq*

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Abstract. This study aims to explore one of the most famous traditional musical instruments of the Sasak culture in Lombok, West Nusa Tenggara, namely the *gendang beleq*, from an ethnomathematics point of view. This study will discuss the relationship between *gendang beleq* and mathematics, as well as to find out how the concepts and principles of geometry are contained in *gendang beleq*. This study is qualitative research with an ethnographic approach (cognitive anthropology) and a theoretical approach to get a description and deep analysis of Sasaknese musical instruments based on their relationship with mathematics. The subjects in this study consisted of two Sasak cultural observers and two *gendang beleq*'s craftsmen. The data in this study are the results of interviews with subjects, observation, and documentation. Data analysis is not only based on the researchers' interpretation but also on the structure of the Sasak community's ideas. The results showed that there were geometric principles and concepts used by the ancestors of the Sasaknese in making *gendang beleq*. The existing geometric concepts include two-dimensional and three-dimensional geometric shapes, the principle of translation, and the principle of dilation. These results are expected to benefit Sasaknese in Lombok, the government of West Nusa Tenggara, and also educators, especially in the field of mathematics by implementing the ideas in teaching and learning.

INTRODUCTION

Mathematics as one of the cultural forms has been integrated into many aspects in society, aware or not [1]. History showed that the emergence of mathematics was related to the cultures from time to time [2]. Basically, mathematics is a symbolic technology developed according to cultural aspects of skills and activities in society [3]. The relation between mathematics and culture is discussed further in ethnomathematics.

D'Ambrosio defined ethnomathematics as mathematics practiced by cultural group (citizen, race, labor, children in certain group ages and professional class) [4]. The ethnomathematical study consists of ethnographical, mathematical modeling, and mathematics [5]–[8]. The intersection of the aspects of a mathematical component, modeling, and ethnography is called by ethnomathematics [9].

The fundamental idea is that mathematics and cultures are integrated. Hence, ethnomathematics will enable people to understand the principles of the mathematics [10]. Various cultural products from the ancestors are the artistic creativity which consists of mathematical ideas, such as the geometrical form of traditional architectures [3], [10]–[12], addition algorithm by indigenous society [1], formal algebra algorithm performed in Madagascar' fortune-telling system [5] and marriage matching system in Javanese Primbon [13].

Other ethnomathematics studies were also conducted to investigate the practice of people in Baduy [14], Javanese [6], [15], [16] (in their households and technology in daily life), technology system [17], traditional cuisine [18] (in geometrical perspective), Malay [19], and the society in Kampung Naga [15]. In a study of ethnomathematics, D'Ambrosio [20] explained the position of ethnomathematics in a theoretical frame to guide the practices and can be used as a curriculum guideline in an educational project. For instance, the study to implement ethnomathematics in mathematics teaching and learning [21]. Ethnomathematics might be used to connect the mathematical concepts and real-life context for the students. Hence, the students will learn

The 1st International Conference on Science Education and Sciences
AIP Conf. Proc. 2619, 090002-1–090002-7; https://doi.org/10.1063/5.0122581
Published by AIP Publishing. 978-0-7354-4446-1/$30.00

mathematics meaningfully. Students will be able to understand the concepts and develop creative thinking skills based on their experiences [22].

The Province of West Nusa Tenggara Barat is one of the provinces with a rich and valuable culture. Not only known for its beauty, but it also has the potency of ethnomathematics. For instance, the architecture of Sasak's traditional house, which is the main part (*bale*) and granary storehouse (*sambi*) [11]. Besides the traditional house, Sasak culture also has the hidden ethnomathematics in their musical instruments of *gendang beleq*.

Gendang beleq is a traditional musical instrument of Sasak. It consists of the elements of *gendang mame*, *gendang nine*, *reyong*, *gong beleq*, *oncer* or *petuq*, *rincik*, and *kenceng* [23]. *Gendang beleq* usually be played in a group, with *bedug* as the main instrument. The *bedug* used in *Gendang beleq* has a relatively different model with others since it is larger. In the initial existence of *Gendang beleq*, it was used as the music when the warriors of Lombok Kingdom went to war. Later in time, *gendang beleq* is used as the traditional music for various local activities such as circumcision ceremony, baby's first hair cut ceremony, and traditional marriage ceremony [24], [25].

The present study aimed to explore the ethnomathematics of musical instrument of Sasak culture in Lombok Island based on the geometrical perspective embodied in *gendang beleq*. The exploration of ethnomathematics in this study will be beneficial for the mathematics educators to develop a set of learning materials with ethnomathematics context, especially in geometry topics.

The study of ethnomathematics has been conducted previously related to its traditional architecture [11]. Since the musical instruments, especially *gendang beleq*, were not discussed yet, this study will explore the mathematical concepts of it.

METHOD

This study is qualitative research. The method was the ethnography approach (cognitive anthropology) [26]. The data were gathered from a literature review of the *gendang beleq* musical instrument, interviews to gain information related to the production process, aim and function of the elements of *gendang beleq* and how to play the instrument. The informants of the study were two craftsmen and two cultural practitioners of *gendang beleq.* All of the informants are male-identified. The data from the interview were typed into a transcript. The data from observation were documented through photos. Both of the data were used to analyze the mathematical concepts of *gendang beleq*. In this study, we merely discuss the *gendang mame* and *gendang nine* by exploring the geometrical objects on it. The data analysis was done by adopting an ethnographic approach according to Spradley [26] by choosing the informants, conducting the interview, creating the ethnography notes, asking descriptive questions, creating domain analysis, ask structural questions, conducting taxonomy analysis, and writing the ethnography.

RESULTS AND DISCUSSION

Results

The observation and documentation results gathered from the direct observation in the location of the study were supported by the interview result from the informants to gain more data. In the following discussion, we will present the geometrical concepts occurred in *gendang beleq* musical instrument. There are two types of *gendang* which is *gendang mame* and *gendang nine* with different size and characteristics. The diameter of *gendang nine* is 1-2 cm larger than *gendang mame* and has a lower tone.

FIGURE 1. *Gendang beleq musical instrument*

Figure 1 is the picture of *gendang beleq* musical instrument. In general, there are four main components of *gendang beleq* which are the surface or the membrane of *gendang* (or usually called as *ramping*), the body of *gendang*, *jangat* or the strings and *wangkis*. The geometrical shape of the *gendang beleq* will be described further in the following discussion.

Two-Dimensional Geometry Objects

There are a number of two-dimensional geometry objects in *gendang beleq*. In Figure 2, the membrane of the sides of the *gendang* created the shape of circle (usually called with *rampeng*) which usually played as the main source of the sound. Besides that, there also a circle in the *wangkis*, which is a string that surround the *rampeng* to support its position.

FIGURE 2. The circles on *rampeng* and *wangkis*

Besides that, there is also the shape of a triangle in *jangat* or the strings between both sides of *rampeng*, which can be seen in the following Figure 3.

FIGURE 3. The isosceles triangle (i) and equilateral triangle (ii) on *jangat*

The last two-dimensional geometry object occurred in *gendang beleq* is a pentagon that can be seen in the Figure 4.

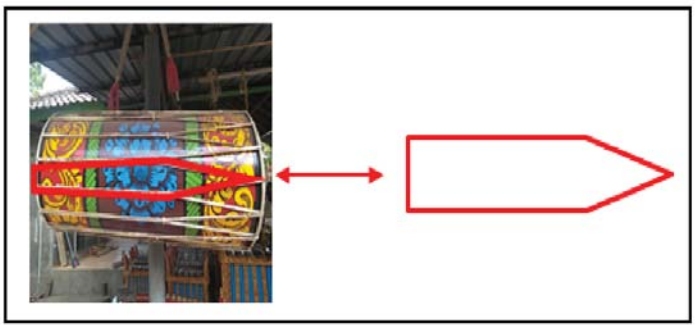

FIGURE 4. Pentagon on *jangat*

Geometry Transformation

Geometry transformation is changing the coordinate of a point on a plane according to certain rule. For instance, the transformation (T) of $P(x, y)$ results on $P'(x', y')$, with the following mathematical operation:

$$P(x, y) \xrightarrow{T} P'(x', y') \quad \text{..... (1)}$$

Some transformation occurred in *gendang beleq* can be explained as follow.

1. Translation

Translation is a transformation which moving the points on an object based on certain distance and direction. Figure 5 showed the translation of *jangat* (the strings of *gendang*) in horizontal direction. The shape and direction is exactly similar with the original shape.

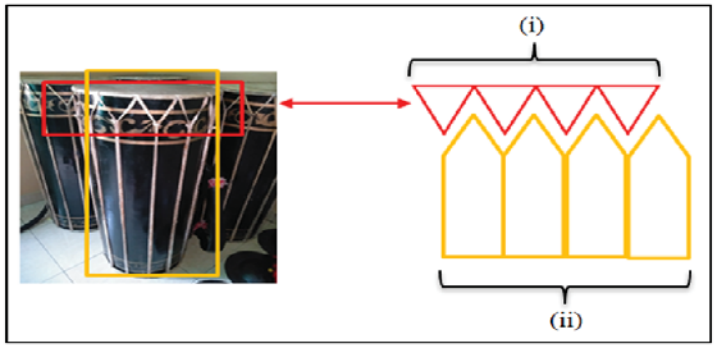

FIGURE 5. The translation of triangle (i) and pentagon (ii) on *jangat*

2. Dilatation

Dilatation is a transformation that change the size or scale of the original object, whitout changing its shape. The dilatation of the object is determined by the scale or dilatation factor. Consider the following Figure 6.

FIGURE 6. Dilatation in *jangat* or strings of *gendang*

3. Three-Dimensional Geometry Objects

Besides the two-dimensional objects, there also a three-dimensional object in *gendang* as can be seen in Figure 7 such as a cylinder or usually called by *tebeng* in Sasak culture.

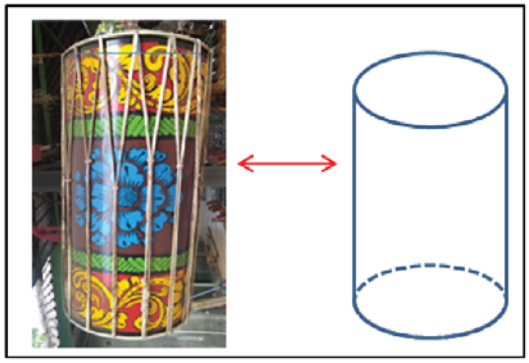

FIGURE 7. Build tube space on the drum trunk or body

Discussion

Ethnomathematics practiced by the Sasaknese can be observed from the traditional musical instrument called *gendang beleq*, one of the famous instruments in Sasak Culture. The musical instrument is not only a creative art product of society but also has mathematical values. There are a number of mathematical principles of the instrument. Some of them will be elaborated in the following discussion.

Two-Dimensional Geometry Objects

There are two-dimensional geometry objects which have the form of a circle (Figure 2) on *rampeng* (the membrane of both sides of the *gendang*) and *wangkis* (the strings that surround the *rampeng*) of *gendang*. The circles are appeared in the top and bottom of the *gendang* and have diameters of 45-50 cm for *gendang nine* and 44-49 cm for *gendang mame* (smaller size). Besides that, there is also a triangular shape in *jangat* that connecting both sides of *rampeng* (Figure 3). The function of the shape is to set the tension level of the *ramping* which will impact the high or low tone of the *gendang*. The triangle is in the form of isosceles which has the equal length on both of the legs. In some *gendang beleq*, the form of *jangat* could also be an equilateral triangle depending on the setting of the strings. The longer the height of the triangle, the higher the tone produced, and vice versa. The other two geometry objects in the figure are irregular pentagon (Figure 4) or usually called as *segi lime* by the Sasaknese.

Geometry Transformation

4. Translation

As is explained previously, translation is a transformation that moves every points of a plane in certain distance and direction. The distance and the direction of the translation could be represented by a line segment, such as $\overrightarrow{AB}$ or a pair of numbers $\binom{a}{b}$, where "a" symbolized the horizontal change and "b" symbolized the vertical change of the distance and direction. In translation, the shape of the objects will not be changed. Mathematically, the operation of translation can be seen as the following expression.

$$A(x,y) \xrightarrow{T=\binom{a}{b}} A'(x',y') = A'(x+a, y+b) \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

If we consider the pattern of the strings in the *gendang* musical instrument, it can be found that it was the result of the horizontal translation of the objects. Hence, the product of the translation is a set of objects with equal shape and size. Figure 5 showed that the pattern was translated in certain distance and direction according to the pattern in equation (2).

5. Dilatation

There is a dilatation concept in *gendang beleq*, which is related to the change of size or scale of the object. Figure 6 showed the dilatation or enlargement of the strings of the *gendang.* Sasaknese called it *pebelek*. Also, from Figure 6 we can observe that there are some scale factors applied such that the size of the strings was not equally same. In the dilation of the strings of the *gendang*, the shapes are similar with the original but the size are different (larger).

As can be observed in Figure 7, there is a cylinder shape in the body of *gendang beleq*. This part is functioned as a resonator of the musical instrument. The Sasaknese called the cylinder as *tebeng*. The length of *tebeng* is 1 m while the diameter of cylinder of *gendang nine* is 45 - 50 cm which is 1 – 2 cm larger than the diameter of *gendang mame*.

Gendang in the *gendang beleq* musical instrument played as the rhythm setter. The strings of *gendang* or *jangat* have various sizes according to the setting such that the tone will not be changed. This study relevant with the study of D'Ambrosio [4], [20] that cultures in society consists of mathematics.

Aware or not, there are some mathematical concepts in *gendang beleq* which were developed by the ancestors of Sasaknese. It can be seen from the principles and concepts of geometry that can be found in *gendang beleq*, including the two-dimensional objects (such as triangle, pentagon and circle), three-dimensional objects (cylinder) and the transformation principles of translation and dilatation. The results of this study confirmed the conclusion from previous study which stated that there is a relation between mathematics and culture [2], [13], [16], for instance in geometry [11], [12], [14], [17] in various regions. Hence, ethnomathematics which is a part of culture in various places might be connected to mathematical lessons.

Hence, further study which focus on the cultural norms and its relation with mathematical concepts should be conducted to enable the implementation of it to the mathematics teaching and learning in the school. By that, we will be able to develop more interesting, meaningful and not too abstract lesson as the chosen context is close to daily life and can be found in the culture.

CONCLUSION

The Sasaknese in Lombok Island is familiar with the geometrical concept, both consciously and unconsciously. It can be seen from the principles and the concepts of geometry found at the *gendang beleq* musical instrument. The result of the study showed that some concepts and principles of geometry on *gendang beleq* are the two-dimensional objects (triangle, pentagon, and circle), three-dimensional objects (cylinder in the body of the instrument), and also the translation and dilation principles on the *jangat*. For further study, it is possible to continue the research and explore more mathematical concepts that can be found in the components of Gendang Beleq such as *reyong*, *gong beleq*, *oncer* or *petuq*, *rincik* and *kenceng*. The results can be implemented in school mathematics, especially on geometry topics.

REFERENCES

1. Haryanto, T. Nusantara, Subanji, and S. Rahardjo, Ethnomathematics in Arfak West Papua-Indonesia Numeracy of Arfak. Int. J. Sci. Technol. Res. **06**, 09, 325–327 (2017).
2. D. Muhtadi, Sukirwan, Warsito, and R. C. I. Prahmana, Sundanese Ethnomathematics: Mathematical Activities in Estimating, Measuring, and Making Patterns. J. Math. Educ. **8**, 2, 185–198 (2017).
3. R. Fitriza, D. Afriyani, Turmudi, and D. Juandi, The Exploration of Ethno-Mathematics Embedded on Traditional Architecture of Rumah Gadang Minangkabau. Advances in Social Science, Education and Humanities Research (ASSEHR) **160**, 270–276 (2017).
4. U. D'Ambrosio, Ethnomathematics and Its Place in the History and Pedagogy of Mathematics. JSTOR **5**, 1, 44–48 (1985).
5. M. Ascher, Malagasy Sikidy: A Case in Ethnomathematics. Hist. Math. **24**, 4, 376–395 (1997).
6. D. A. Kusuma, S. P. Dewanto, B. N. Ruchjana, and A. S. Abdullah, "The Role of Ethnomathematics in West Java (A Peliminary Analysis of Case Study in Cipatujah)," In *J. Phys. Conf. Ser.*, (IOP Publishing, 2017) 893, 012020, pp. 1–8.
7. Bender and S. Beller, Ethnomathematics and Numerical Cognition. The International Encyclopedia of Anthropology. JohnWiley & Sons, Ltd, 1–10 (2018).
8. V. Albanese and F. J. Perales, Enculturation With Ethnomathematical Microprojects: From Culture to Mathematics. J. Math. Cult. **9**, 1–11 (2015).
9. M. Rosa and D. C. Orey, Ethnomodelling as a Research Theoretical Framework on Ethnomathematics and Mathematical Modelling. J. Urban Math. Educ. **6**, 2, 62–80 (2013).
10. Küçük, Ethnomathematics in Anatolia-Turkey: Mathematical Thoughts in Multiculturalism. Rev. Latinoam. Etnomatemática **7**, 1, 171–184 (2014).
11. S. Supiyati, F. Hanum, and Jailani, Ethnomathematics in Sasaknese Architecture. J. Math. Educ. **10**, 1, 47–57 (2019).

12. C. Ditasona, "Ethnomathematics Exploration Of The Toba Cmmunity: Elements of Geometry Transformation Contained in Gorga (Ornament on Bataks House)," in *IOP Conf. Ser. Mater. Sci. Eng.* (IOP Publishing, 2018) **335**, 1, 1–6.
13. N. W. Utami, S. A. Sayuti, and Jailani, Math and Mate in Javanese Primbon: Ethnomathematics Study. J. Math. Educ. **10**, 3, 341–356 (2019).
14. Arisetyawan, D. Suryadi, T. Herman, and C. Rahmat, Study Ethnomathematics : A Lesson of Baduy Culture. Int. J. Educ. Res. **2**, 10, 681–688 (2014).
15. T. Septianawati, Turmudi, and E. Puspita, "Ethnomathematics Study: Uncovering Units of Length, Area, and Volume in Kampung Naga Society," in *J. Phys. Conf. Ser.*, (IOP Publishing, 2017) 812, 012021, pp. 1–7.
16. S. Abdullah, "Ethnomathematics in Perspective of Sundanese Culture," J. Math. Educ. **8**, 1, 1–16 (2017).
17. K. Pramudita and R. Rosnawati, "Exploration of Javanese Culture Ethnomathematics Based on Geometry Perspective,"in *J. Phys. Conf. Ser.*, (IOP Publishing, 2019) 1200, 012002, pp. 1–8.
18. Zaenuri and N. Dwidayati, "Exploring ethnomathematics in Central Java," in *J. Phys. Conf. Ser.*, (IOP Publishing, 2018) 983, 012108, pp. 1–6.
19. N. A. Adam, "Mutual Interrogation: A Methodological Process in Ethnomathematical Research," in *Procedia - Social and Behavioral Sciences International Conference on Mathematics Education Research 2010 (ICMER) 2010*, 8, pp. 700–707.
20. U. D'Ambrosio and B. S. D'Ambrosio, The Role of Ethnomathematics in Curricular Leadership in Mathematics Education. J. Math. Educ. Teach. Coll., **4**, 32–38 (2013).
21. S. Supriadi, S. Susilawati, and B. Tristyanto, "Ethnomathematics in Mathematics, Social and Physical Education," in *J. Phys. Conf. Ser.*, (IOP Publishing, 2019) 1318, 012126.
22. D. Novitasari, T. W. Triutami, N. P. Wulandari, A. Rahman, and Alimuddin, "Students' creative Thinking in Solving Mathematical Problems Using Various Representations," in *Advances in Social Science, Education and Humanities Research (ASSEHR), Proceedings of the 1st Annual Conference on Education and Social Sciences (ACCESS 2019)*, 2020, 465, pp. 99–102.
23. G. A. M. Saputra, Kajian Instrumentasi dan Organologi Gendang Beleq Sanggar Mertaq MI Lombok Tengah Nusa Tenggara Barat. Sorai J. Pengkaj. dan Pencipta. Musik **12**, 2, 57–69 (2019).
24. N. K. Sumardi, Evolusi Gendang Beleq Lombok. Gondang J. Seni dan Budaya **1**, 2, 63–69 (2018).
25. F. Saifuddin, Denotative and Connotative Meaning ff Signs in Lombok Musical Instrument (Gendang Beleq). Int. J. English Lit. Soc. Sci. **3**, 1, 97–100 (2018).
26. J. P. Spradley, *The Ethnographic Interview* (Harcourt Brace Jovanovich College Publisher, Florida, 1988).